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Renewable energy in five South East Asian countries: Review on electricity consumption and economic growth

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ABSTRACT

The present study is an archival-statistical overview of the possibility of renewable energy production in five South East Asian countries and their economic capacity. The five South East Asian countries under review are the Philippines, Thailand, Malaysia, Indonesia, and Singapore, all of which have a combined population of 420 million. This number is a little less than the population of 25 European countries. These five countries have created a large market in the world and have enjoyed significant economic growth in recent years. Tropical climate in the region facilitates the potential for using clean and green energies. This article clarifies the effective relation between energy capacities and economic indices in these countries and analyzes the results. Using a survey, the paper shows that despite the shortage of energy in these countries brought by their fast economic growth, the share of renewable energy in energy production is constantly declining and more reliance is still placed on fossil fuels for energy production.

Contents

1. Introduction

The Philippines, Thailand, Malaysia, Indonesia, and Singapore have a combined economy of US $75 billion, which is almost equal to India's economy. These South East Asian countries comprise half of the 10 countries of the Association of Southeast Asian Nations (ASEAN), which is known as one of the strongest and most active regional treaties in the world. ASEAN, which has a 45-year history, is regarded as an effective driver of the Asian economy, together with China and India [1]. ASEAN countries are composed of two parts, namely, northern and southern areas. The northern part includes Laos, Vietnam, and Cambodia, whereas the southern part includes Thailand, Malaysia, the Philippines, Indonesia, Singapore, and Brunei. ASEAN countries strive for common goals, and by establishing various internal treaties, they plan to accelerate their industrialization process [2]. In this regard, the role of energy in the development and growth of ASEAN member countries is significant and worthy of investigation.

Energy has a significant role in ASEAN economic integration. A list of different energy sources and their capacity is shown in Table 1.

The ASEAN vision 2020 adopted in 1997 introduced new cooperation in electricity and natural gas sectors. Trans-ASEAN gas pipeline projects and ASEAN power grid are some of these new collaborations [4].

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Table 1
ASEAN energy capacity [3].

Energy	Capacity
Oil	22 billion barrels
Natural gas	227 trillion cubic feet
Coal	46 billion tons
Hydropower	234 GW
Geothermal	20 GW

The ASEAN action plan, which was formulated between 1999 and 2004, discusses an integrated energy network for South East Asian countries, created from gas pipeline and power grid projects [5].

The average annual energy consumption for the ASEAN is 3.9%; this rate is calculated from the ASEAN consumption of 343 Million Tonnes of Oil Equivalent (MTOE) in 2005 to 901 MTOE in 2030 [6]. The highest annual consumption is projected to be 5.1%. This consumption is dividable to different sectors. The highest consumption growth belongs to electricity generators, which is 6.1% per annum. Consumption in the industrial sector is 4.6% on average per annum, whereas commercial, residential, and agricultural sectors grow by 2.4% annually. The annual growth of gas, oil, coal, and biomass is 5.0%, 4.5%, 5.9%, and 0.2%, respectively. Oil will be the main source of energy in the ASEAN until 2030 [6]. The share of oil consumption from 40.9% in 2005 will increase to 41.5% in 2030. Nuclear energy will be part of the consumption in 2030, but will account for only 1.5%. ASEAN economic growth increases carbon emission in the region by 5.1%. CO_2 emission per unit likewise increases from 0.52 kt-C/TOE in 2005 to 0.68 kt-C/TOE in 2030. This increasing trend in carbon emission is visible on the Gross Domestic Product (GDP) per capita as well [4].

2. Economic indices of the five South East Asian countries under review

The ASEAN was established in Thailand in 1967. The first ASEAN agreement, known as Bangkok declaration, was signed by Malaysia, Philippines, Singapore, Thailand, and Indonesia [1]. Neighboring countries joined the association later: Brunei in 1984, Vietnam in 1995, Laos and Myanmar in 1997, and Cambodia in 1999.

The counties reviewed in this work are the first five members of this treaty, that is, the Philippines, Thailand, Malaysia, Indonesia, and Singapore. According to the reports by the International Monetary Fund (IMF) in April 2012, these countries will have steady and less volatile economic growth over the coming years. As shown in Fig. 1, after the global economic crisis in 2008 and the sharp drop in global growth rate, all five countries managed to overcome the crisis, such that Singapore experienced growth of over 14% in 2010. These five countries are predicted to experience growth of between 4% and 7% over the coming years [7].

According to ASEAN agreements and treaties, member countries are engaged in economic interactions and energy exchanges. Despite the competition with one another, member countries participate in regional cooperation [8]. With its population of 240 million, Indonesia has the largest market in South East Asia; this figure, similar to that in the four other countries, has enjoyed a significant growing trend in recent years. Fig. 2 illustrates the market size of each country [9].

Meanwhile, significant differences can be seen among these countries. Per capita income is one of the obvious economic differences among these countries. Although the per capita income of people in this region has increased in the last 30 years, the level of income has varied for different countries. As Fig. 3 shows, Singapore has the highest per capita income among the five countries at US $60,000 in 2012. Income from technological

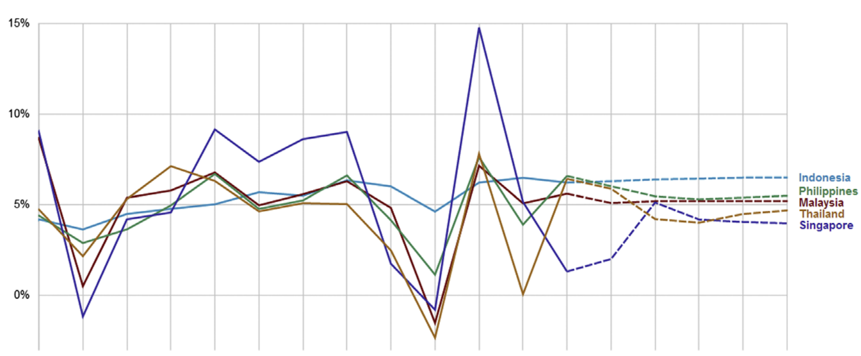


Fig. 1. GDP constant prices (% change) in the five South East Asian countries (2000–2011) [7].

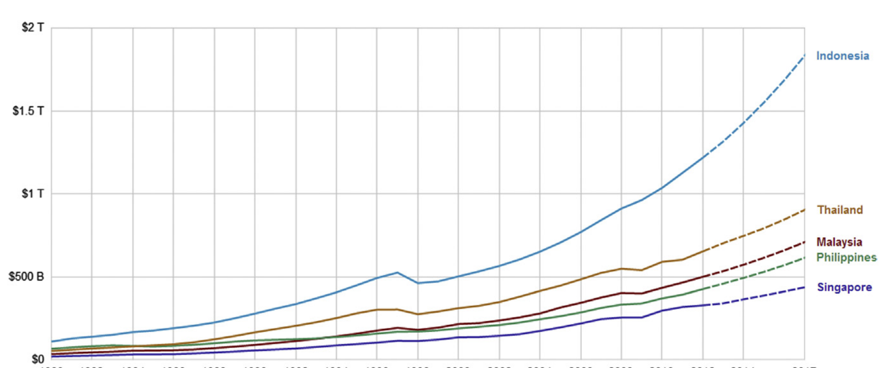


Fig. 2. GDP based on purchasing power parity (PPP) valuation of country GDP in the five South East Asian countries (1980–2011) [9].

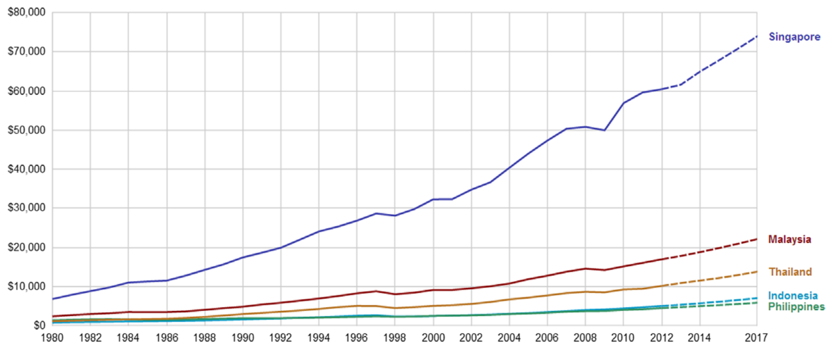


Fig. 3. GDP based on PPP per capita GDP of the five South East Asian countries (1980–2011) [10].

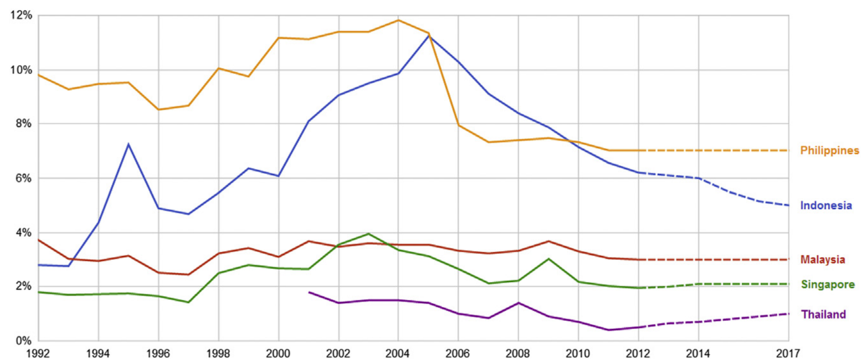


Fig. 4. Unemployment rate in the five South East Asian countries (1992–2011) [11].

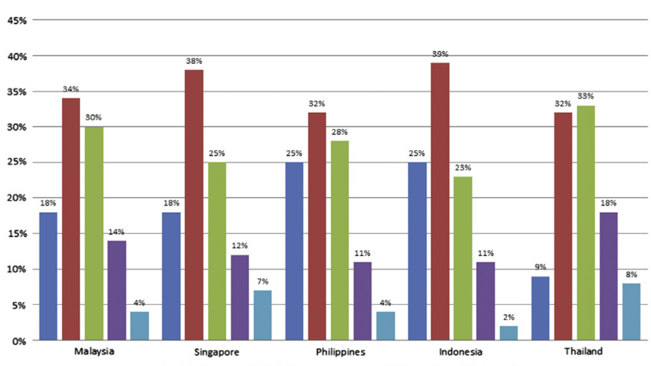


Fig. 5. Optimism on the employment condition in the five South East Asian countries in 2012 [12].

industries and commerce contributed to this high figure. By contrast, Filipinos earn only about US $5000 a year [10].

Given the considerable economic growth, increase in employment is expected in these countries. According to the IMF, the unemployment rate is presently over 7% in Indonesia and the Philippines, 3.5% in Malaysia, 2.2% in Singapore, and 1% in Thailand, all of which are lower than the average global unemployment rate (Fig. 4). Unemployment is one of the indices that guarantee the veracity of a country's economic growth [11].

The unemployment rate in Thailand and Singapore is even lower than the natural unemployment rate, which is 3%. Fig. 5 shows the optimism on the employment situation in the countries under review from the perspective of regional experts. Accordingly, except for Thailand, most experts predict that the future condition of employment in Malaysia, Indonesia, the Philippines, and Singapore will be better than that in 2011. Regarding Thailand, however, most experts believe that the current trend will continue. Obviously, this optimism on employment is due to the growing optimism on the economic growth in these countries [12].

Improvement in employment gives rise to increase in national income and stable economic growth as well as increase in savings [13] among the people in this region of the world such that the gross national savings have been very significant since 2000. Fig. 6 shows, the gross national savings have always been more than 20% in the Philippines, more than 25% in Thailand, more than 30% in Malaysia, and more than 35% in Singapore. Indonesia's gross national saving rate has risen from 15% in 1999 to more than 30% in 2012 [14].

Although the increase in savings naturally leads to increase in investment [15], optimism from global economies and the prediction of stable growth rate in South East Asia have caused investment in these countries to increase sharply.

Fig. 7 shows the increase in the level of investments and the diversity of investments in the five countries under review. National savings in these countries have increased such that, in only 10 years, about 10% of their international loans and bonds will be reduced [16].

Stable economic growth requires energy at fixed prices [17]. Nevertheless, crude oil price fluctuation from global threats and sanctions against oil-producing countries has greatly lowered the expectation of energy price stability in the future. A scrutiny of crude oil price fluctuations in the past 60 years shows (Fig. 8) that oil price has never had a stable and reliable condition in the long term, and aside from domestic supply and demand of countries, political crises and international relations have always affected oil price [18]. In addition, hidden charges are imposed on oil-consuming countries for developing oil transport infrastructure and repairing such infrastructure.

Such instability in oil prices in the international markets in the past 10 years, which has been associated with unprecedented increase in prices, has greatly increased the desire for investment

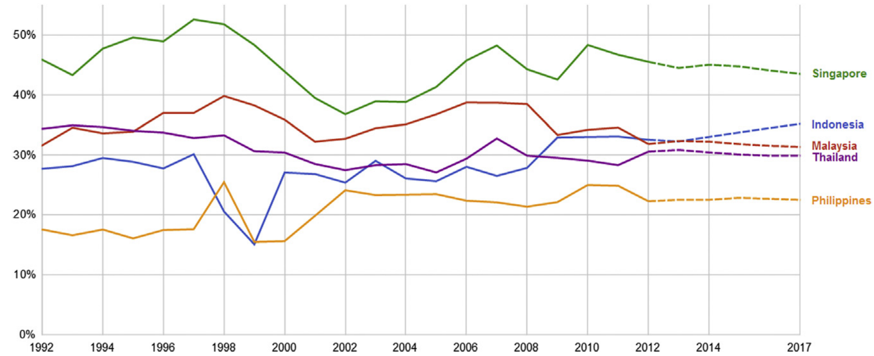


Fig. 6. Gross national savings (% of GDP) of the five South East Asian countries (1992–2011) [14].

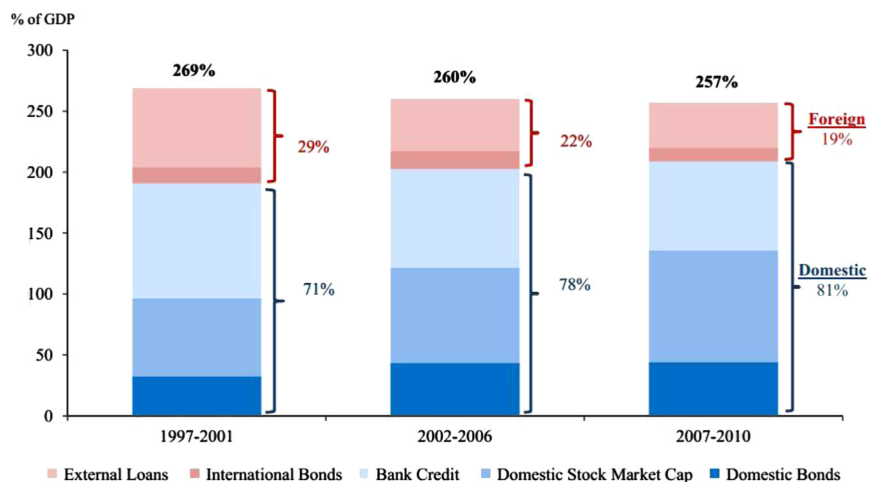


Fig. 7. Major sources of funds in the five South East Asian countries (1997–2010) [16].

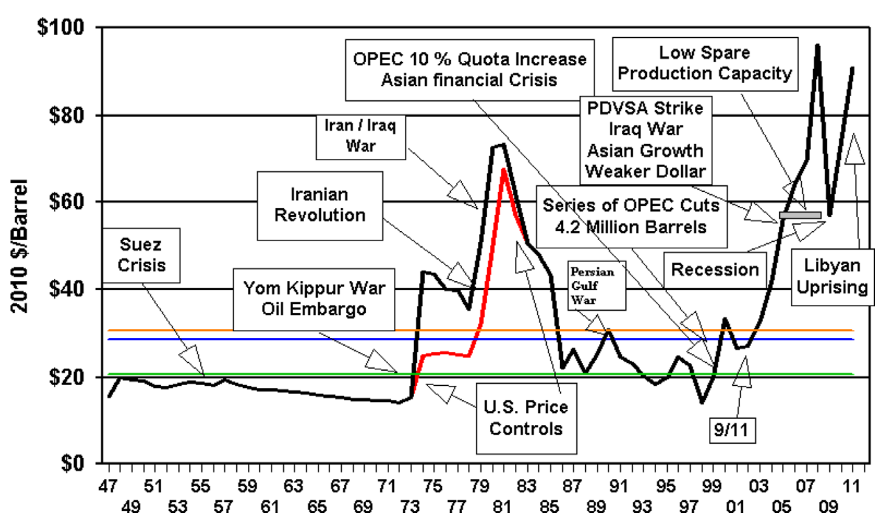


Fig. 8. History of crude oil prices from 1947 to 2011 [18].

in alternative energies. Invulnerability of renewable energy prices to global policies and political crises can guarantee the stability and possibility of long-term planning for developing countries. This paper examines whether the development process in these five South East Asian countries has resulted in the reduction of their reliance on oil as the main energy carrier. Moreover, this work will explore the effective factors in economic growth and determine if the development process in these countries has resulted in the substitution of oil with renewable energies.

3. Energy situation in five South East Asian nations

3.1. The Philippines

The Philippines is a South East Asian country composed of 7107 islands located within the South China Sea and the West Pacific Ocean [19]. It has a population of 93 million, and is regularly subjected to destructive and deadly natural disasters, such as earthquakes, volcano eruptions, and massive typhoons. The

Philippines has the world's 45th largest safe economy, and its main exports include electronic products and equipment, semiconductors, textile, copper, tropical fruits, and coconut oil [20].

Despite its numerous islands and large population, 97% of the Philippines' urban population has access to public electricity. For the rural population, this rate is 65%. The per capita electricity consumption is 586 kWh a year; a liter of gasoline and a liter of diesel trade for US $0.91 and US $0.81, respectively [21]. The level of energy efficiency in the Philippines is 0.09 (TOE per US $1000, adjusted for PPP).

According to the latest published statistics, about 16% of the Philippines' electricity is generated from hydropower, 19% from renewable energies, and the rest from thermal power plants. Studies show that the Philippines is capable of producing 5.1 kWh/m^2/day from solar farms, but this country only generates 1 MW of its electricity from solar power [22]. The Philippines is constantly exposed to severe storms, something which has been per se considered a potential for electricity generation. This country can theoretically produce 76,600 MW and technically 7404 MW of electricity from wind power. However, it currently produces about 1.18 MW of its electricity from wind power [23].

The Philippines is rich in freshwater resources; therefore, generating electricity from hydropower has always been a priority for its government. Technically, the Philippines can produce 11,223 MW of electricity in small and large scales. It also has the ability to produce 1847 MW at a mini scale and 27 MW at a microscale [24]. Moreover, the Philippines can commercially produce 20 MW of biomass-sourced electricity.

Considering the tropical nature as well as the rich, varied, and large farms in this country, the Philippines has the advantage of utilizing farm and livestock waste for biogas production. Furthermore, using such natural resources has long been common in this country. Currently, 653 biogas systems are active around large farms in the Philippines [22].

The amount of CO_2 produced per person in the Philippines is 0.9 metric ton, which is considered a very low figure. The annual amount of electricity generated from coal has had an escalating rate over the past years from 53 billion kWh in 2000 to about 100 billion kWh in 2006; in 2007, this figure reached 120 billion kWh [25].

Fig. 9 shows that the total amount of energy produced from renewable sources has gradually grown with some changes from 30 billion kWh in 1997. It has fluctuated between 40 and 50 billion kWh in recent years.

Despite the increasing energy demand and consumption of fossil fuels, the rate of using renewable energies has declined from about 30% in 1995 to less than 20%. The total amount of energy consumption of the Philippines in 2007 is equivalent to 310,000 kt of oil [21].

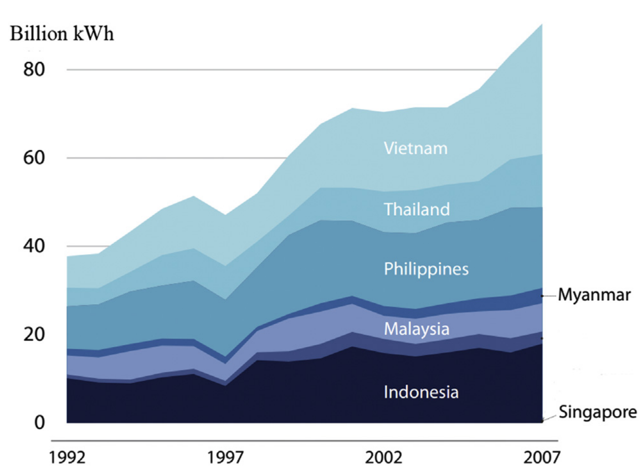


Fig. 9. Total energy produced from renewable sources in the five South East Asian countries (1997–2007) [21].

3.2. Thailand

Thailand, formerly known as Siam, is located in the center of Indochina Peninsula. Similar to other tropical countries, Thailand is abundant in water resources and dense forests. According to a 2010 census, the country has a population of 65,479,453. From 1985 to 1995, Thailand enjoyed the world's highest real economic growth with an average growth of 9%, but the outbreak of a financial crisis in 1996–1997 slowed its industrialization and economic growth [26].

Its most common exported goods include agricultural products, such as rice and natural rubber, textiles, shoes, jewelry, and electronic equipment. Thailand is one of the most successful Asian countries in the distribution of energy; 100% of its urban population and 99% of its rural population have access to the electricity network. The per capita electricity consumption in Thailand is 2055 kWh per person, annually. Energy efficiency is 0.19 (TOE per US $1000, adjusted for PPP). A liter of gasoline costs US $0.87, whereas a liter of diesel is US $0.64 [21].

At present, less than 8% of the electricity in Thailand is generated from hydropower. The amount of electricity generated from renewable sources is about 4%, and the rest comes from fossil fuels. Thailand is considered as a country rich in solar energy; the potential for solar radiation in this country is 5.1 kWh/m^2/day. At present, 31 MW of electricity in Thailand is generated from solar energy [22]. Thailand has the advantage of using wind energy for electricity production; theoretically, it can produce 3 MW of electricity by utilizing wind with speeds of 7–8 m/s and 52 MW of electricity by utilizing wind with speeds of 8–9 m/s. Technically speaking, Thailand has the ability to produce 1600 MW of electricity, of which 1 MW is sourced from wind power [27].

In theory, Thailand can produce 700 MW of hydropower in microscale, and presently, it generates 139 MW of that potential and distributes it in the network. As for biomass sourced energy, Thailand can technically produce 7000 MW of energy, and approximately 1610 MW of electricity is obtained from this source at present. Compared with its neighboring countries, such as the Philippines and Indonesia, Thailand is very rich in geothermal energy [22]. Thailand's capacity for geothermal energy production is 5.3 MW, but in practice, only 1 MW of geothermal energy is produced and used. The capacity for biogas energy production in Thailand is approximately 278 MW, but formally, it produces and supplies 20 MW of biogas energy [27].

The amount of CO_2 emitted per person in Thailand is 4.1 metric tons, annually [28]. The annual amount of electricity generated from coal has had a rising rate over the past years, from about 75 billion kWh in 2000 to around 120 billion kWh in 2006; in 2007, the figure is 140 billion kWh [21].

Amid fluctuations, the total amount of energy produced from renewable sources has been growing slowly from 37 billion kWh in 1997 to about 60 billion kWh in recent years [27]. Compared with the case in the Philippines, the increasing need for energy in Thailand in recent years has not necessarily led to increased consumption of fossil fuels. With the increasing need for energy, the increasing consumption of fossil fuel use has decreased the use of renewable energies from 24% in 1995 to 20% in the 1997 to 1999. In 2003, renewable energy accounted for less than 17% of the total energy, but it has enjoyed a gradual growth in the following years. Despite the high energy consumption in Thailand, the share of renewable energies during 2003–2007 has increased by about 2%. By the end of 2007, Thailand's total energy consumption was equivalent to 460,000 kt of oil [21].

3.3. Malaysia

Malaysia is mainly composed of two large peninsulas, home to a population of 29,365,000 and diverse geography. The main peninsula neighbors Thailand and Singapore in the north; the lower part of the country neighbors Brunei, and the east territories of Indonesia in the East [29]. Traditionally, Malaysia is dependent on oil for energy, huge sources of which exist in Malaysia's eastern coasts. Among the five countries under review, Malaysia has the lowest population density. Its low population and rich vast lands have facilitated this country's move to renewable energies compared with its neighbors. The total capacity of electricity in Malaysia is 13 GW [30], 84% of which is generated in thermal power plants and 16% in hydropower plants [22]. The entire urban population and 98% of Malaysia's rural population have access to the national electricity network [31]. The per capita electricity consumption in Malaysia is 3667 kWh per person in a year. The price of gasoline and diesel in this country is US $0.53 per liter [21]. Energy efficiency in Malaysia is 0.25 (TOE per US $1000, adjusted for PPP).

On average, the solar radiation potential in Malaysia is about 4.5 kWh/m^2/day, which is considered as a desirable level for producing solar energy [32]. Presently, energy is produced in two forms, namely, stand-alone panels for houses and solar farms. The amount of energy produced by stand-alone panels is about 1.5 MWp, and the amount of energy provided by solar farms is 450 MWp [22]. In 2012, this amount became 140 MW [33]. Given the high amount of energy from different renewable sources, providing energy from wind power has no place in Malaysia, only in some small islands, where about 0.15 MW of electricity is generated from this kind of energy.

Technically, Malaysia can produce 29,000 MW of hydropower energy, and at present, more than 2000 MW of Malaysia's electricity is produced in large scale from this source, with 40 MW of its electricity generated in mini scale from hydropower. With regard to the mass production of palm oil in Malaysia, producing abundant biomass energy is possible; Malaysia can produce 29,000 MW of electricity from this source. Currently, 211 MW of electricity is produced via this source [22].

Although Malaysia enjoys considerable geothermal sources, with exceptional characteristics in Sabah and Sarawak, and its government has invested heavily on it, this source has not produced electricity for use in the electricity network [34]. Biogas is another source that remains underexploited for electricity generation.

The amount of CO_2 emission per capita in Malaysia is about 7.52 metric tons [35]. The amount of electricity produced from coal has been rising, from 40 billion kW in 2000 to about 60 billion kW in 2006 and 90 billion kW in 2007.

The amount of total energy produced from renewable sources has fluctuated since 1997, which was equivalent to 15 billion kW in that year [36]. However, this number has risen to 26 billion kW in recent years. Despite the increased electricity production from renewable energies in Malaysia (similar to the Philippines), the share of electricity production from renewable sources has decreased relative to the total of produced energy, and from 1995 to 2007, it has decreased from 7% to 5%. In 2010, the total energy consumption of Malaysia was about 270,000 kt of oil [21].

3.4. Indonesia

With a population of over 239,870,000 and area of 1,919, 440 km^2, Indonesia is the largest and most populous country in South East Asia [37]. Indonesia is composed of five major islands and 13,677 small islands, among which more than 7600 islands are inhabited. This country has the world's largest and longest volcanic mountains, located in Java and Sumatra [38]. This geography has caused the country to lag behind the four other countries in the region in the field of power distribution in that only 94% of its urban population and 32% of its rural population have access to the national electricity network. The annual electricity consumption of a typical Indonesian is about 566 kWh. The prices of petrol and diesel are US $0.50 and US $0.42, respectively. Energy efficiency is 0.32% in this country (TOE per US $1000, adjusted for PPP) [21].

A total of 10% of Indonesia's energy is produced from hydropower sources, 27% from renewable sources, and the rest from thermal power plants. On average, the potential of solar radiation is 4.8 kWh/m^2/day in Indonesia [22]. At present, 5 MW of energy is produced from this source and is consumed in the country. Studies show that the location of Indonesia is conducive for producing energy from wind power with a speed of 3–6 m/s, but in the current condition, only 0.5 MW of energy is produced [39].

As Indonesia enjoys abundant water supply, this country has the potential for producing water energy. Theoretically, this country can produce 75,000 MW in large scale and 459 MW in mini and microscales [22]. At present, however, 4200 MW of hydropower energy in large scale and 64 MW in mini and microscales are produced in this country. Technically, Indonesia can produce about 50,000 MW of biomass energy; in practice, 312 MW of biomass energy is produced.

Indonesia is the best country in producing geothermal energy. Investigations show that it has the potential to produce 27,000 MW of electric power via geothermal energy [40]. With 802 MW of geothermal energy, Indonesia has the largest supply of this kind of energy among the countries under study. In contrast to using biomass energy, geothermal energy is not in the agenda of Indonesian planners, and no significant amount of electricity is obtained from this source.

The amount of CO_2 emission per person is 1.7 metric tons in Indonesia [41]. The amount of annual electricity produced from coal has had an ascending rate, from 35 billion kW in 2000 to about 50 billion kW in 2006 and 60 billion kW in 2007.

The total amount of energy produced from renewable sources has fluctuated since 1997, which was equivalent to 7 billion kW in that year. However, it has been 17 billion kW in recent years. Despite the increase in energy produced from renewable sources in Indonesia, as in the Philippines, the percentage of electricity produced from renewable sources has slightly decreased relative to the total energy produced, and from 1995 to 2007, it decreased from 37% to 27%. In 2010, the total energy consumption is about 195,000 kt of oil in this country [21].

3.5. Singapore

Singapore is an island south of Malaysia that has the highest per capita income, the smallest area, and the smallest population among the other countries under review. Singapore's population is 5,076,700, and its area is about 780 km^2 [42]. The entire Singaporean population has access to the electricity network. The per capita electricity consumption of Singapore is about 8514 kWh per year. The prices of gasoline and diesel are US $1.07 and US $0.90, respectively. Energy efficiency in Singapore is 0.2% (TOE per US $1000, adjusted for PPP) [21]. The entire energy demand in Singapore is supplied via thermal resources, and hydropower energy plays no role in supplying energy in this country. Similar to Indonesia, the rate of solar radiation in Singapore is 4.5 kWh/m^2/day, but electricity produced from solar panels is only about 90 kWp [22].

Singapore has not shown interest in investing in wind energy production, and in fact, no energy is produced from wind power in this country. Biomass energy production is limited to 220 MW of

wood waste. Biogas and geothermal energy are not produced in Singapore, and on the whole, the portion of renewable energies from the total energy produced in Singapore is about 0%. About 80% of electricity in Singapore is produced through burning gas [43].

The amount of CO_2 emitted per person is about 12.8 metric tons. Annual electricity production from coal is about 0% in this country. The total energy consumption is 35,000 kt of oil [21].

4. Discussion and data analysis

Analysis of the statistics tabulated above shows that some of the economic indices as well as energy production and consumption statistics have meaningful relationships (direct or inverse relationships) that merit consideration. (Table 2)

From the analysis of the presented table, the following are gleaned:

(a) As expected, a direct relationship exists between electricity consumption per capita and purchasing power in the five South East Asian countries. Increasing purchasing power leads to increased electricity consumption per capita (Fig. 10).

(b) A third relationship exists between electricity consumed per capita and purchasing power and CO_2 emission. In the five countries, increased purchasing power results in increased energy consumed per capita, and as this energy is provided by fossil fuels, CO_2 emission likewise increases, which is not seen in Fig. 9 because the carbon emission number is too small.

(c) Analysis of the potentials in consumption of renewable resources in the five countries shows that no relationship exists between the potential of renewable energies and energy generation in these countries. Thus, the adopted policies by the governments of the five South East Asian countries for consuming renewable energies have no harmony with the potential rates in their respective countries. Among the five countries, Malaysia has the least potential for solar radiation, but in practice, this country has had the most policies concerned with the production of solar energy and electricity. Malaysia's potential of 4.5 kWh/m^2/day is equal to 140 MW, which is more than that of the Philippines and Thailand (potential of 5.1 kWh/m^2/day). Concerning biomass, although Indonesia and Malaysia have the most potential for producing electricity from biomass, the Philippines, producing 1610 MW of electricity has practically the highest rate in this area. In the field of geothermal energy, nevertheless, most of the sources for producing this kind of energy are in Indonesia, but the Philippines' production of geothermal electricity is twice more than Indonesia's. Although areas in South East Asia enjoy a high potential for producing wind energy, the amount of produced electricity does not correspond with the potentials of these countries.

(d) Contrary to the opinion of many energy policy makers, the analysis of CO_2 emission and gasoline and diesel prices shows that increased fuel price is not equivalent with decreased consumption and, consequently, decreased CO_2 emission. Among the countries under investigation, Singapore has the

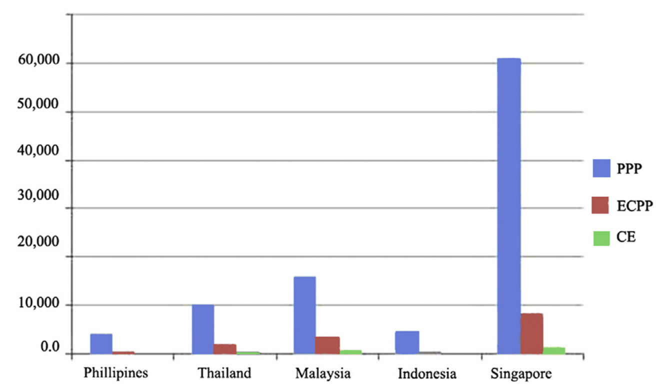


Fig. 10. Direct relationship between PPP, ECPP, and CE.

Table 2
Data on the five South East Asian countries.

	Philippines	Thailand	Malaysia	Indonesia	Singapore
Population (2010)	93,260,798	65,479,453	28,401,017	239,870,937	5,076,700
GDP (current price/2012) (billion USD)	227.584	377.158	305.826	928.274	270.02
Average GDP growth (2000–2002)	4.91	4.17	5.01	5.68	6.18
Income (PPP per capita/2012)	4214	9979	16,186	4943	61,046
GNS (% of GDP/average, 2002–2012)	22.94	29.76	34.66	29.36	43.31
Total energy consumption (KTOE)	310,000	460,000	270,000	195,000	350,000
Electricity consumed per person (kWh)	586	2055	3667	566	8514
Energy efficiency (tons of oil equivalent per US $1000, adjusted for PPP)	0.09	0.19	0.25	0.23	0.2
Electricity from coal (billion kW in 2007)	120	140	90	60	0
Electricity from renewable (billion kWh in 2007)	50	60	26	17	0
Hydropower (% of total)	16	8	16	10	0
Renewable (% of total)	19	4	0	27	0
Conventional electricity (% of total)	65	88	84	63	100
Solar potential radiation (kWh/m^2/day)	5.1	5.1	4.5	4.8	4.5
Solar practical (MW)	1	31	140	5	0
Wind potential (MW)	76,600	(7–8 m/s): 3000 (8–9 m/s): 52	No info.	No info.	No info.
Wind practical (MW)	1.18	1	0.15	0.5	0
Biomass potential (MW)	20	7000	29,000	50,000	No info.
Biomass practical (MW)	0	1,610	211	312	220
Geothermal potential (MW)	2600	5.3	No info.	27,000	No info.
Geothermal practical (MW)	1930	1	No info.	802	0
Biogas potential (MW)	No info.	278	No info.	No info.	No info
Biogas practical (MW)	No info.	20	No info.	No info.	0
CO_2 emission (per person in metric tons)	0.9	4.1	7.2	1.7	12.8
Access to electricity in urban areas (%)	97	100	100	94	100
Access to electricity in rural areas (%)	65	99	98	32	100
1 l of petrol (US $)	0.91	0.87	0.53	0.50	1.07
1 l of diesel (US $)	0.81	0.64	0.53	0.42	0.90

highest fuel price, annual per capita energy consumption, and per capita CO_2 emission.

(e) An indirect relationship is seen between per capita income and renewable energy consumption, demonstrated by the lowest consumption of renewable energies in Singapore and high per capita income in Malaysia. The chart below presents the lowest percentage of renewable energy consumption in countries with high per capita income. In the following chart, the figures for per capita income and renewable energy are presented close to each other (Fig. 11).
Certainly, high-income countries do not necessarily give up production of renewable energies. On the contrary, this phenomenon indicates that, by increasing industrialization, the need for fuel to compensate industrial requirements increases the use of fossil fuels against sustainable energies and decreases the percentage of renewable energy consumption. Thus, the highest percentage of electricity production from renewable sources belongs to Indonesia (27%) and the Philippines (19%), whose per capita incomes are below US $5000 per year.

(f) Contrary to common belief, the data analysis for these countries shows that consumption of fossil fuels has no relationship with the amount of CO_2 emission. Singapore, which is the most polluted country among these five countries, has no power plants for producing electricity from coal. Malaysia, placed after Singapore with 7.2 metric tons of CO_2 emission per capita, has a coal consumption rate less than that of Thailand and the Philippines. Singapore has recently built new coal power plants, which are not yet operational.

(g) Electricity distribution in these countries depends on certain factors other than price. Geographical dispersion, population distribution, political and economic stability, as well as the aim of the government to improve services have had positive effects on electricity distribution in urban and rural areas. Consequently, a country such as Indonesia, which is a populous country with numerous islands, runs into more difficulties compared with the other countries.

(h) Among the countries under investigation, Malaysia has the highest energy efficiency rate. This energy efficiency, which depends on the proportion of the price of energy and the purchasing power of people, shows that the expense for providing energy in the Philippines is noticeably higher than that in Thailand and Indonesia.

(i) Contrary to the first claim in the previous section, the high rate of savings has not led to investment on renewable energies. Singapore and Malaysia have the highest rates of savings in GDP among the five countries. However, this factor has not led to the production of electricity from renewable energies in both countries in the past 10 years.

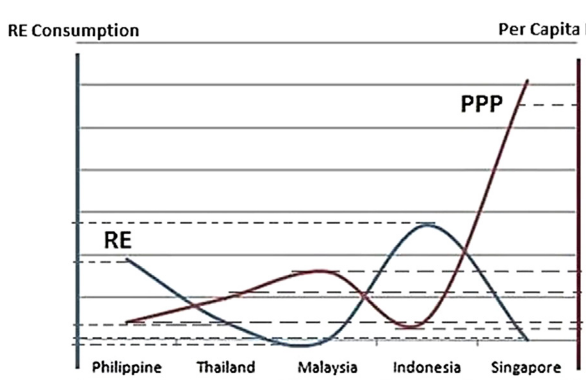


Fig. 11. Inverse relationship between Renewable Energy consumption (RE) and purchasing power parity (PPP) in the five South East Asian countries.

5. Conclusion

A study of the economic indices and energy statistics of the five South East Asian countries shows that the economy of these nations is dependent on three main carriers of energy, namely, oil, gas, and coal. With regard to the abundance of water resources in these countries, hydropower has also been considered along with the three mentioned fossil fuels. Despite the shortage of energy in these countries caused by the increasing demand amid continuous and stable economic growth, renewable energy sources have not had a major role in this respect. Although economic prosperity and stability in these countries have resulted in significant reduction of unemployment, increased purchasing power for citizens, and increased saving rates over the past 10 years, no trace of small and large savings directed toward the generation of renewable energies can be seen. Some economic and energy indices have a significant relationship with one another in these countries, among which is the direct correlation among per capita income, carbon dioxide emissions, and energy consumption. Moreover, an inverse relationship exists between per capita income and use of renewable energy in the countries discussed. Considering the fuel prices and per capita income in these countries, Filipinos suffer the most financial pressure for producing energy whereas Malaysian people enjoy the best conditions. Briefly, the efficiency of produced energy and its trend over the past 10 years suggest the governments' lack of conviction in renewable energies and continued reliance on fossil fuels, especially on oil. In this respect, Singapore generally has shown no interest in renewable energies as source of energy supply for the growing needs of the country. Despite all the potentials available in Malaysia and all the efforts undertaken, the percentage of electricity generated from renewable energies, including renewable sources, in the production cycle of the country remains at the lowest possible. Compared with its growth rate in the use of renewable energy, Thailand's economic growth rate is so high that the share of using renewable energy is eclipsed by the total energy consumption each year; this process is expected to continue. Among the five South East Asian countries, the Philippines, which is rich in renewable energy sources and has the highest rate of using renewable energy sources, is more under consideration compared with the others. Therefore, more governmental support and incentive policies are required for maintaining the existing share. Similar to the Philippines, Indonesia has abundant renewable energy sources, but similar to Thailand, its economic growth rate and increasing consumption of fossil fuels have reduced its share of renewable energy use each year.

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